

## Description

# A GOLF CLUB HEAD WITH A FACE INSERT

### CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a continuation-in-part of U.S. Patent Application Number 10/361,438, filed on February 10, 2003, which claims the benefit of U.S. Provisional Application Number 60/358,450, filed on February 19, 2002.

### FEDERAL RESEARCH STATEMENT

[0002] [Not Applicable]

### BACKGROUND OF INVENTION

[0003] Field of the Invention

[0004] The present invention relates to a golf club head. More specifically, the present invention relates to a golf club head with a face insert.

[0005] Description of the Related Art

[0006] High performance drivers employ relatively thin, high strength face materials. These faces are either formed into the curved face shape then welded into a driver body

component around the face perimeter, or forged into a cup shape and connected to a body by either welding or adhesive bonding at a distance offset from the face of up to 0.75 inch. In a popular embodiment of the sheet-formed face insert driver, the weld between the formed face insert and the investment cast driver body is located on the striking face, a small distance from the face perimeter. It is common practice for the face insert to be of uniform thickness and to design the surrounding driver body component to be of equal thickness. In this way there is continuity of face thickness across the weld.

- [0007] Most face inserts are composed of a titanium alloy material. Titanium alloys are generally classified into three types depending on the microstructure of the material developed after processing of the material. The three types are alpha alloys, alpha-beta alloys and metastable beta alloys, and these represent the phases present in the alloy at ambient temperatures. At ambient temperatures, the thermodynamic properties of titanium favors the alpha phase. However, alloying titanium with other elements allows for the high temperature beta phase to be present at ambient temperatures, which creates the alpha-beta and metastable beta microstructures. The metastable phase

may be transformed into the alpha phase by heating the alloy to an intermediate elevated temperature, which results in a metastable titanium alloy with increased static strength.

[0008] Such high strength metastable titanium alloys have been used as face inserts for drivers with a high coefficient of restitution. However, the heat treatment process compromises the toughness of the material, where toughness is defined as the resistance of the material to fracture under loading. Thus, even heat treated, high strength, metastable titanium alloys have limited application as face inserts due to inferior fracture properties. Thus, there is a need for face inserts composed of titanium alloys with an appropriate microstructure for better fracture properties. This requires a proper balance between strength and toughness (resistance to fracture), without a substantial increase in the costs associated with manufacturing the face insert.

[0009] Several patents disclose face inserts. Anderson, U.S. Patent Numbers 5,024,437, 5,094,383, 5,255,918, 5,261,663 and 5,261,664 disclose a golf club head having a full body composed of a cast metal material and a face insert composed of a hot forged metal material.

- [0010] Viste, U.S. Patent Number 5,282,624 discloses a golf club head with a cast metal body and a forged steel face insert with grooves on the exterior surface and the interior surface of the face insert and having a thickness of 3mm.
- [0011] Rogers, U.S. Patent Number 3,970,236, discloses an iron club head with a formed metal face plate insert fusion bonded to a cast iron body.
- [0012] Galloway, *et al.*, U.S. Patent Number 6,354,962 discloses a golf club head of a face cup design.
- [0013] Laminated inserts for golf club heads are well-known in the patented prior art as evidenced by Mahaffey *et al.*, U.S. Patent Nos. 5,827,131 and 6,074,309. Both patents disclose inserts formed of outer metal layers and an inner layer, where the outer layers are higher density and stronger than the inner layer. The inserts are connected to the golf club head by weld, adhesive, crimping, or other methods known to the art.
- [0014] It is also known in the art to manufacture certain components of a golf club head using explosion bonding. Ciasullo, U.S. Patent No. 6,739,984, discloses a golf club head in which a sole plate and top plate each include an inner shell of less dense material which is explosion bonded to the respective plate. The components are then

welded together to form a golf club head.

[0015] However, there is a need for a golf club head with a face insert that performs better than conventional face insert club heads and provides cost savings.

## SUMMARY OF INVENTION

[0016] In prior art laminated striking plate inserts for golf club, the bonding strength of the laminate is usually quite low; it is generally lower than the yield strength of the weakest material. Additionally, explosion welding has previously only been used to join the sole plate or the top plate of a golf club head. The present invention overcomes the problems of the prior art by providing a golf club head that has a body with a laminated striking plate insert that is manufactured by an explosion bonding process. The golf club head preferably has a large volume, a large moment of inertia about the center of gravity, a high COR, and a deep face. This allows the golf club head of the present invention to have better performance than a conventional face insert golf club head.

[0017] Having briefly described the present invention, the above and further objects, features and advantages thereof will be recognized by those skilled in the pertinent art from the following detailed description of the invention when

taken in conjunction with the accompanying drawings.

## BRIEF DESCRIPTION OF DRAWINGS

- [0018] FIG. 1 is an exploded view of the components of a preferred embodiment of the golf club head of the present invention.
- [0019] FIG. 2 is a front view of a golf club head of the present invention.
- [0020] FIG. 3 is a top plan view of a golf club head of the present invention.
- [0021] FIG. 4 is a side view of the heel end of a golf club head of the present invention.
- [0022] FIG. 5 is side view of the toe end of a golf club head of the present invention.
- [0023] FIG. 6 is a bottom plan view of a golf club head of the present invention.
- [0024] FIG. 7 is a rear view of a golf club head of the present invention.
- [0025] FIG. 8 a front view of a golf club head of the present invention showing the perimeter region in dashed lines.
- [0026] FIG. 9 is a cross-sectional view along line 9-9 of FIG. 3.
- [0027] FIG. 10 is a sectional view of an alternative embodiment of a golf club head having a striking plate insert.

- [0028] FIG. 11 is a sectional view of an alternative embodiment of a golf club head having striking plate insert.
- [0029] FIG. 12 is an exploded view of a preferred embodiment of a laminated insert.
- [0030] FIG. 13 is a cross-sectional view of an alternative embodiment of a laminated explosion bonded striking plate insert.
- [0031] FIG. 13A is an exploded view of an alternative embodiment of a laminated insert.
- [0032] FIG. 14 is a cross-sectional view of a preferred embodiment of a laminated explosion bonded striking plate insert.
- [0033] FIG. 15 is an enlarged detail of the sectional view of FIG. 14.

#### **DETAILED DESCRIPTION**

- [0034] As shown in FIGS. 1–9, the golf club head of the present invention is generally designated 20. The golf club head 20 of FIGS. 1–9 is a driver, however, the golf club head of the present invention may alternatively be a fairway wood. The golf club head 20 has a body 22 that is preferably composed of a metal material such as titanium, titanium alloy, or the like, and is most preferably composed of a cast titanium alloy material. The body 22 is preferably cast

from molten metal in a method such as the well-known lost-wax casting method. The metal for casting is preferably titanium or a titanium alloy such as 6-4 titanium alloy, alpha-beta titanium alloy or beta titanium alloy for forging, and 6-4 titanium for casting. Alternatively, the body 22 is composed of 17-4 steel alloy. Additional methods for manufacturing the body 22 include forming the body 22 from a flat sheet of metal, super-plastic forming the body 22 from a flat sheet of metal, machining the body 22 from a solid block of metal, electrochemical milling the body from a forged pre-form, casting the body using centrifugal casting, casting the body using levitation casting, and like manufacturing methods.

- [0035] The golf club head 20, when designed as a driver, preferably has a volume from 200 cubic centimeters to 600 cubic centimeters, more preferably from 300 cubic centimeters to 460 cubic centimeters, and most preferably from 360 cubic centimeters to 425 cubic centimeters. A golf club head 20 for a driver with a body 22 composed of a cast titanium alloy most preferably has a volume of 380 cubic centimeters. The volume of the golf club head 20 will also vary between fairway woods (preferably ranging from 3-woods to eleven woods) with smaller volumes

than drivers.

- [0036] The golf club head 20, when designed as a driver, preferably has a mass less than 225 grams, and most preferably a mass of 180 to 215 grams. When the golf club head 20 is designed as a fairway wood, the golf club head preferably has a mass of 135 grams to 180 grams, and preferably from 140 grams to 165 grams.
- [0037] The body 22 preferably has a crown 24, a sole 26, a ribbon 28, and a front wall 30 with an opening 32 or alternatively with a recess 45. The body 22 preferably has a hollow interior 34. The golf club head 20 has a heel end 36, a toe end 38 and an aft end 37. A shaft, not shown, is placed within an interior hosel 35 at the heel end 36. The interior hosel 35 is within the hollow interior 34 of the body 22, and the interior hosel 35 extends from the crown 24 to the sole 26. The interior hosel 35 is preferably cast with the entirety of the body 22. However, the interior hosel 35 may be a separate component that is attached through welding or other means to the body 22. Those skilled in the art will recognize that the golf club head 20 of the present invention alternatively may have an external hosel 15, such as shown in FIGS. 10-11, without departing from the scope and spirit of the present invention.

tion.

[0038] In a preferred embodiment, the golf club head 20 preferably has a striking plate insert 40 that is attached to the body 22 over the opening 32 of the front wall 30. As shown in FIG. 1, the striking plate insert 40 is preferably welded to the front wall 30 of the body 22, thereby covering the opening 32. A plurality of tabs 47, preferably three, align the striking plate insert 40 for the welding process. Alternatively, the striking plate insert 40 is press-fitted into the opening 32. As shown in FIG. 1, the striking plate insert 40 typically has a plurality of score-lines 45 thereon.

[0039] As shown in FIG. 15, the striking plate insert 40 is preferably composed of a first layer 61, a second layer 65 and a third layer 63. The first layer 61 and the third layer 63 are preferably composed a high strength material such as a titanium alloy material, a steel alloy material, a beryllium-copper material, or a forging brass. Each of the first layer 61 and the third layer 63 preferably has a thickness ranging from 0.025 inch to 0.200 inch, more preferably 0.050 inch to 0.150 inch, and most preferably 0.060 inch. The second layer 65 is preferably composed of a low density material such as an aluminum alloy, aluminum, pure tita-

nium, magnesium alloys, and other like material. The second layer 65 preferably has a density less than 5.0 grams per cubic centimeter ("g/cc"), and more preferably less than 3.0 g/cc. The second layer preferably has a thickness ranging from 0.025 inch to 0.200 inch, more preferably 0.050 inch to 0.150 inch, and most preferably 0.060 inch.

[0040] Alternatively, the striking plate insert 40 comprises only two layers as shown in FIG. 13. The first layer 61 is preferably composed a high strength material such as a titanium alloy material, a steel alloy material, a beryllium-copper material, or a forging brass. The first layer 61 preferably has a thickness ranging from 0.025 inch to 0.200 inch, more preferably 0.050 inch to 0.150 inch, and most preferably 0.060 inch. The second layer 65 is preferably composed of a low density material such as an aluminum alloy, aluminum, pure titanium, magnesium alloys, and other like material. The second layer 65 preferably has a density less than 5.0 grams per cubic centimeter ("g/cc"), and more preferably less than 3.0 g/cc. The second layer preferably has a thickness ranging from 0.025 inch to 0.200 inch, more preferably 0.050 inch to 0.150 inch, and most preferably 0.060 inch. This embodiment of the striking plate insert 40 is particularly suitable

for use with a club head including a backing plate 45 such as shown in FIG. 11.

[0041] The materials of the laminate are preferably joined by explosion bonding or welding to form a finished striking plate insert 40. According to a preferred embodiment, the layers are initially arranged in spaced relation as shown in FIGS. 12 and 13. In FIG. 12, the first layer 61 forms the striking face of the golf club head 20, and the third layer 63 forms the rear face of the striking plate insert 40. An explosive is applied to the rear surface of the rear third layer 63 and a detonator is connected with the explosive. When the detonator is activated, the explosive accelerates the third layer 63 into bonding contact with the second or center layer 65 which is then accelerated into bonding contact with the front first layer 61, as shown by the arrows between the layers of FIG. 12. A similar arrangement is shown in FIG. 13, where the first layer 61 forms the striking face of the golf club head, and the second layer 65 forms the rear face of the striking plate insert 40. An explosive is applied to the rear surface of the rear second layer 65 and a detonator is connected with an explosive. When the detonator is activated, the explosive accelerates the rear second 65 into bonding contact with the first

layer 61, as shown by the arrows in FIG. 13A. Those skilled in the art will recognize other methods for explosion bonding non-similar materials.

- [0042] Explosion bonding provides metal-to-metal bonding between the layers without generating excessive heat in the layers. In FIG. 14 is shown the explosive bonded layers 61, 63, and 65 of the laminate of FIG. 12.
- [0043] The spacing between the layers prior to explosion bonding is a function of the materials being bonded. Typically, the distance is from 0.5 to 4 times the thickness of the layers. For example, an arrangement with two outside layers of a high strength material such as 6-4 titanium with a thickness of approximately 0.06 inch (1.5mm) and an inner layer of less dense material such as aluminum with a similar thickness of approximately 0.06 inch (1.5mm) would require a spacing between the layers prior to explosion from 0.03 inch (0.75mm) to 0.24 inch (6.0 mm). When the explosive is ignited, the detonation travels across the surface of the third layer 63 and the gas expansion of the explosion accelerates the third layer 63 toward the second layer 65. Because of the rapid movement of the third layer toward the second layer, pressure is created at the opposing surfaces of the layers to remove sur-

face contaminants therefrom, resulting in a metal-to-metal bond between the clean metal surfaces when the outer layer collides with the inner layer. The same occurs between the second layer 65 and the front first layer 61.

[0044] As shown in FIG. 15, the interfaces between the explosion bonded layers have a wavy bond morphology. The metallurgical bond results from the interface between the grains of the different metal layers. Although the explosion bonding process generates heat, the heat is not transferred to the metal layers, because bonding occurs so quickly. Thus, there is no melting or diffusion of the layers. Accordingly, high yield strengths are obtained.

Typically, the yield strength of the laminate is similar to or greater than the full strength characteristics of the materials used in the laminate.

[0045] In a preferred embodiment, the striking plate insert 40 has a uniform thickness that ranges from 0.050 inch to 0.250 inch, more preferably a thickness of 0.080 inch to 0.120 inch, and is most preferably approximately 0.110 inch.

[0046] The present invention is directed at a golf club head that has a high coefficient of restitution thereby enabling for greater distance of a golf ball hit with the golf club head

of the present invention. The coefficient of restitution (also referred to herein as COR) is determined by the following equation:

$$e = \frac{v_2 - v_1}{U_1 - U_2}$$

[0047] wherein  $U_1$  is the club head velocity prior to impact;  $U_2$  is the golf ball velocity prior to impact which is zero;  $v_1$  is the club head velocity just after separation of the golf ball from the face of the club head;  $v_2$  is the golf ball velocity just after separation of the golf ball from the face of the club head; and  $e$  is the coefficient of restitution between the golf ball and the club face.

[0048] The values of  $e$  are limited between zero and 1.0 for systems with no energy addition. The coefficient of restitution,  $e$ , for a material such as a soft clay or putty would be near zero, while for a perfectly elastic material, where no energy is lost as a result of deformation, the value of  $e$

would be 1.0. The present invention provides a club head 20 preferably having a coefficient of restitution preferably ranging from 0.80 to 0.94, and more preferably from 0.82 to 0.87, and most preferably from 0.84 to 0.85, as measured under standard USGA test conditions.

- [0049] The depth, "D", of the club head 20 from the striking plate insert 40 to the aft-end 37 preferably ranges from 3.0 inches to 4.5 inches, and is most preferably 3.75 inches. The height, "H", of the club head 20, as measured while in address position, preferably ranges from 2.0 inches to 3.5 inches, and is most preferably 2.50 inches or 2.9 inches. The width, "W", of the club head 20 from the toe end 38 to the heel end 36 preferably ranges from 4.0 inches to 5.0 inches, and more preferably 4.7 inches.
- [0050] As shown in FIG. 9, the distance, "Hf", between the lowest point of the sole 26 when the golf club head 20 is in the address position and the lowest point of the striking plate insert 40 is preferably approximately 0.5 inch. Further, the weld between the striking plate insert 40 and the body 22 is preferably approximately 0.03 inch, which provides for a more compliant face resulting in a higher COR.
- [0051] The center of gravity and the moments of inertia of the golf club head 20 may be calculated as disclosed in U.S.

Patent Number 6,607,452, entitled High Moment Of Inertia Composite Golf Club, and hereby incorporated by reference in its entirety. In general, the moment of inertia, I<sub>zz</sub>, about the Z axis of the center of gravity for the golf club head 20 will preferably range from 2700g·cm<sup>2</sup> to 4000g·cm<sup>2</sup>, more preferably from 3400g·cm<sup>2</sup> to 3900g·cm<sup>2</sup>. The large I<sub>zz</sub> value improves shot straightness and distance for heel-toe hits. The moment of inertia, I<sub>yy</sub>, about the Y axis for the center of gravity of the golf club head 20 will preferably range from 2000g·cm<sup>2</sup> to 3000g·cm<sup>2</sup>. The large I<sub>yy</sub> value improves the backspin robustness and distance for both high and low hits on the face.

[0052] The following is a list of examples of materials that can be used for the layers of the insert:

MATERIAL	TENSILE STRENGTH (psi)	YIELD STRENGTH (psi)	DENSITY (lb /cu. in.)
356 Aluminum	40000	27000	0.097
7075 Aluminum	83000	73000	0.101
Forging Brass	55000	20000	0.305
BE-CU	110000	90000	0.297
304 Stainless	85000	35000	0.290
431 Stainless	125000	95000	0.280
17-4 Stainless	150000	110000	0.280
99.0% Titanium	79000	63000	0.163
6-4 Titanium	135000	120000	0.160

[0053] Examples of some of the above materials for construction of the laminate are as follows:

FACE LAYER	CENTER LAYER	BACK LAYER
17-4 Stainless	99.0% Titanium	17-4 Stainless
6-4 Titanium	7075 Aluminum	6-4 Titanium
BE-CU	356 Aluminum	BE-CU
Forging Brass	256 Aluminum	Forging Brass
431 Stainless	7075 Aluminum	17-4 Stainless
304 Stainless	356 Aluminum	7075 Aluminum
431 Stainless	7075 Aluminum	431 Stainless

[0054] From the foregoing it is believed that those skilled in the

pertinent art will recognize the meritorious advancement of this invention and will readily understand that while the present invention has been described in association with a preferred embodiment thereof, and other embodiments illustrated in the accompanying drawings, numerous changes, modifications and substitutions of equivalents may be made therein without departing from the spirit and scope of this invention which is intended to be unlimited by the foregoing except as may appear in the following appended claims. Therefore, the embodiments of the invention in which an exclusive property or privilege is claimed are defined in the following appended claims.